The 2nd International Conference on Flexible Electronics
July 13 – July 14, 2019, Hangzhou, China

Highly Stretchable and Self-Healing Hydrogel-Based Flexible Sensor with Multi-Functionalities

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Abstract

Flexible sensory electronics have received extensive interest due to its simple device configuration, high sensitivity and easy signal processing.[1-3] Hydrogels, which are highly biocompatible, nontoxic and environmentally friendly, are promising in tissue engineering, artifcial actuators and soft electronics. However, traditional hydrogel suffers from poor stretchability and is subjected to irreversible mechanical failure. Herein, highly stretchable, piezoresistive and self-healing hydrogel-based flexible sensors are fabricated. Firstly, polyacrylamide-polyvinyl alcohol (PAM-PVA) composite hydrogel with self-patterned morphology was used as building blocks of sensor.[4] The hydrogel exhibited impressive stretchability (> 500% strain) and superior transparency (> 90%), furthermore, the self-patterned micro-architecture on the hydrogel surface was beneficial to achieving high sensitivity (0.05 kPa^{-1} for 0 - 3.27 kPa). Various dynamic pressures (3.33, 5.02 and 6.67 kPa) monitoring, fast response time (150 ms), durable stability (500 dynamic cycles) and negligible current variation (6%) were also integrated into the hydrogel-based sensor (Figure 1). More importantly, highly stretchable (> 550% strain), self-healing (497% healed strain with 90.4% healing efficiency after 6h) and anti-freezing (502% strain after freezing under -25℃) binary networked hydrogel-based flexible sensors were prepared.[5] The hydrogel-based sensor behaved fast electrical self-healing (125 ms), which was promising for soft circuit. After being crushed into fragments, the hydrogel could be remolded, which was conducive to renewable electronics (Figure 2).

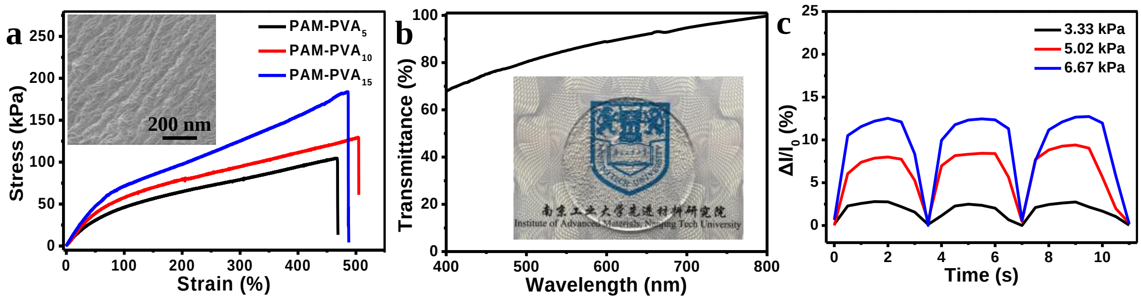

Figure 1. a) The high stretchability of the PAM-PVA composite hydrogel. Inset shows the self-patterned surface formed during the preparation procedure. b) The high transparency (92% transmittance at 650 nm) of the hydrogel. c) Relative current variation of the hydrogel-based sensor under different pressures (3.33, 5.02, and 6.67 kPa).

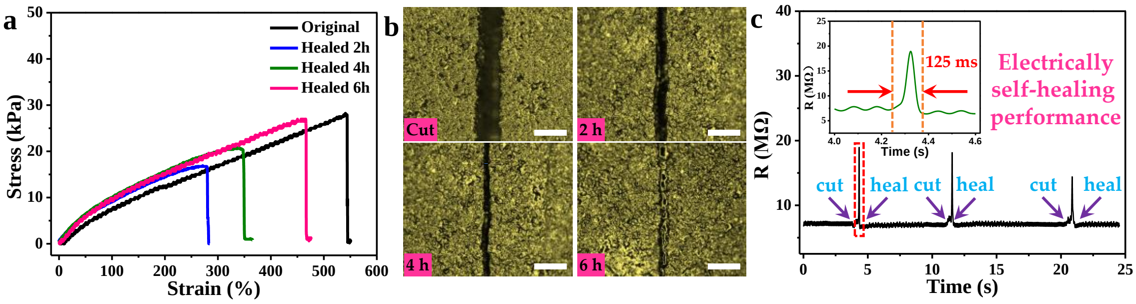

Figure 2. a) Stress–strain curves of the self-healing hydrogel before and after self-healing for 2, 4 and 6 h. b) Microscopic images of the scratch on the hydrogel surface after self-healing for 2, 4 and 6 h. Scale bar: 100 μm. c) Electrically self-healing performance of the hydrogel-based sensor during three cut-heal cycles. Inset shows the electrical healing time during the first cutting-healing cycle.

References

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